EFFECTS OF NH3 PLASMA PRETREATMENT ON THE GROWTH OF CARBON NANOTUBES

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Abstract

Since the first discovery of carbon nanotubes (CNTs) in 1991[1], CNTs have attracted much attention. CNTs exhibit unique electronic and extraordinary mechanical properties. They have many potential applications. There are various synthetic methods for the production of CNTs[2-7]. CVD methods have many advantages. In CVD, it is believed that the catalyst on the substrate must be in the form of particles instead of smooth, continuous films and the CNT diameter tends to depend on the size of the catalyst particles. These catalysts can be deposited onto the substrate from solutions with pre-formed particles[8]or by physical techniques[9]. Physical techniques are quick, easy, and amenable to produce small patterns. The film thickness is a crucial parameter for the diameter and the density of the CNTs. The island size depends on the thickness of the initial catalyst films. Typical thin catalyst film thickness should be less than 20 nm. While the catalyst film thickness is more than 30 nm, a small grain size is not guaranteed. It is very difficult to grow thinner CNTs. Pretreatment further to break the film into desired particles should be taken.

NH3 is believed to be essential to the growth of CNTs in the CVD system[10]. The purpose of this paper is to study the pretreatment effect of NH3 plasma on CNT growth. In this paper, multi-wall carbon nanotubes have been grown on silicon substrates with NH3 plasma pretreatment to the thick catalyst films by CVD using C2H2/NH3 mixtures. The morphology and structure of carbon nanotubes were studied by scanning electron microscopy and transmission electron microscopy. Both concentric hollow and bamboo-type multi-wall carbon nanotubes were observed. The diameter, density, morphology and structure of carbon nanotubes changed with the plasma power and pretreatment time.

Under our experimental conditions, we believe the effects of NH3 plasma pretreatment for the nanotube growth by controlling the NH3 plasma power and pretreatment time in CVD method. CNTs grown on the substrate showed fairly good morphology. However, during pretreatment, using NH3 only without plasma resulted in worm-like carbon fibers. The NH3 plasma resulted in melting and roughening of the substrate surface, and this enhanced the formation of metal particles. It is confirmed that NH3 plasma plays an important role in promoting the formation of uniformly separated particles and reducing Fe. The ion bombardment energy in NH3 plasma leads to the thick catalyst film to particles, yielding the nanotube-growth enhancement. The results show that NH3 plasma density was found to be the primary factor in synthesizing CNTs during the pretreatment. NH3 plasma power and pretreatment time have to be optimized in order to grow uniform and density controlled nanotubes.

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